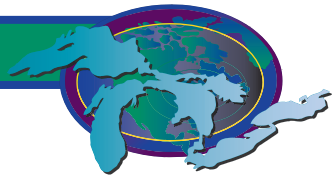

Biological Markers of Human Exposure to Persistent Chemicals

Indicator #4177

Overall Assessment

Status: **Not Assessed**
Trend: **Undetermined**
Rationale: **At present, no routine Great Lakes human biomonitoring programs exist to monitor biological markers of human exposure to persistent chemicals. Individual epidemiological studies have been conducted or are ongoing in the Great Lakes to monitor specific populations. For this reason, the overall status and trends are both undetermined.**

Lake-by-Lake Assessment

Individual lake assessments can not be determined for this indicator. Instead, a list of ongoing research funded by the Agency for Toxic Substances and Disease Registry (ATSDR), through its Great Lakes Human Health Effects Research Program, is provided according to the institution conducting the research.

Lake Superior

Status: Not Assessed
Trend: Undetermined
Rationale: No studies funded by ATSDR are currently being conducted by any institution in the Lake Superior basin. However, basin-wide studies do incorporate Lake Superior information.

Lake Michigan

Status: Not Assessed
Trend: Undetermined
Rationale: *Health Effects of PCB Exposure from Contaminated Fish* (Susan L. Schantz, Ph.D., University of Illinois at Urbana-Champaign);
Organo-chlorides and Sex Steroids in two Michigan Cohorts (Janet Osuch, M.D., Michigan State University);
A Pilot Program to Educate Vulnerable Populations about Fish Advisories in Upper Peninsula of Michigan (Rick Haverkate, M.P.H., Inter-Tribal Council of Michigan, Inc.)

Lake Huron

Status: Not Assessed
Trend: Undetermined
Rationale: No studies funded by ATSDR are currently being conducted by any institution in the Lake Huron basin. However, basin-wide studies do incorporate Lake Huron information.

Lake Erie

Status: Not Assessed
Trend: Undetermined
Rationale: No studies funded by ATSDR are currently being conducted by any institution in the Lake Erie basin. However, basin-wide studies do incorporate Lake Erie information.

Lake Ontario

Status: Not Assessed
Trend: Undetermined
Rationale: *Neuropsychological and Thyroid Effects of PDBEs* (Edward Fitzgerald, Ph.D., State University of New York at Albany);
PCB Congener and Metabolite Patterns in Adult Mohawks: Biomarkers of Exposure and Individual Toxicokinetics (Anthony DeCaprio, Ph.D., State University of New York at Albany);
Neurobehavioral Effects of Environmental Toxics - Oswego Children's Study: Prenatal PCB Exposure and Cognitive Development (Paul Stewart, Ph.D., State University of New York at Oswego)

Purpose

- To assess the levels of persistent toxic substances such as methyl mercury, PCBs, and DDEs in the human tissue of citizens of the Great Lakes basin
- To infer the efficacy of policies and technology to reduce these persistent bioaccumulating toxic chemicals in the Great Lakes ecosystem

Ecosystem Objective

Citizens of the Great Lakes basin should be safe from exposure to harmful bioaccumulating toxic chemicals found in the environment. Data on the status and trends of these chemicals should be gathered to help understand how human health is affected by multimedia exposure and the interactive effects of toxic substances. Collection of such data supports the requirement of the Great Lakes Water Quality Agreement Annex 1 (Specific Objectives), Annex 12 (Persistent Toxic Substances), and Annex 17 (Research and Development) (United States and Canada 1987).

State of the Ecosystem

Women and Infant Child Study

Data presented for this indicator are solely based upon one biomonitoring study that Wisconsin Department of Public Health (WiDPH) conducted in the basin (Anderson 2004). However, information on previous biomonitoring studies has been collected and is highlighted as a way to support the results of the WiDPH study and to illustrate previous and other ongoing efforts.

In the study conducted by WiDPH, the level of bioaccumulating toxic chemicals was analyzed in women of childbearing age 18 to 45 years of age. Hair and blood samples were collected from women who visited one of six participating Women Infant and Child (WIC) clinics located along Lake Michigan and Lake Superior. Levels of mercury were measured in hair samples, and mercury, PCBs, and DDEs were measured in blood serum. Awareness of fish consumption advisories was assessed through a survey.

There was greater awareness of fish consumption advisories in households in which someone fished compared to those in which no one did (Figure 1), and there was greater awareness of advisories from individuals with at least a high school education compared to those with only some high school or less education (Figure 2). More women in the 36 to 45 age category were aware of advisories than those of other ages, but there was less than 50% awareness in all age classes (Figure 3). More Asian women were aware of advisories that those of other races, and Hispanic women were least aware of the advisories (Figure 4).

Sixty-five hair samples were analyzed for mercury levels. The average mercury concentration in hair from fish-eating women was greater than that from non-fish eaters, ranging from 128% increase in women who ate few fish meals to 443% increase in those who ate several meals of sport-caught fish (Table 1).

Five samples of blood were drawn and analyzed for PCBs, DDEs and mercury levels. Although the small sample

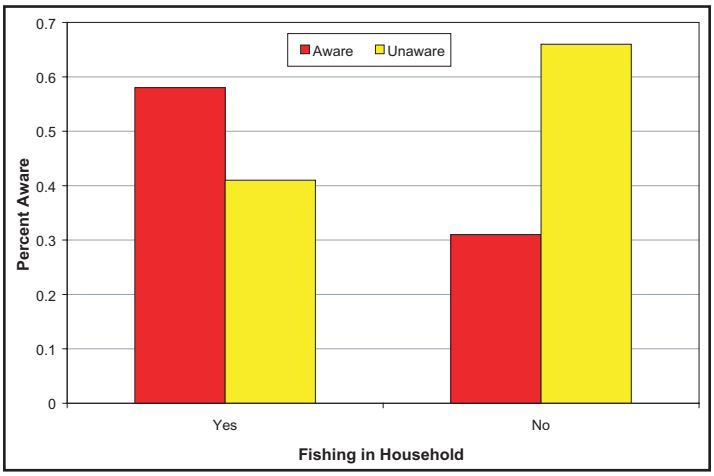

Figure 1. Percent of responders to the survey who are (red) or are not (yellow) aware of fish consumption advisories and who do (yes) or do not (no) have someone in the household who fishes.
Source: Wisconsin Department of Health and Family Services

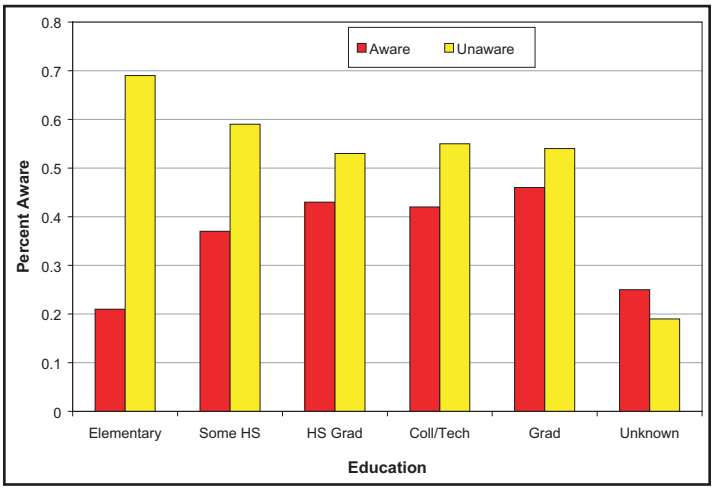

Figure 2. Percent of responders to the survey who are (red) or are not (yellow) aware of fish consumption advisories according to level of education.
Source: Wisconsin Department of Health and Family Services

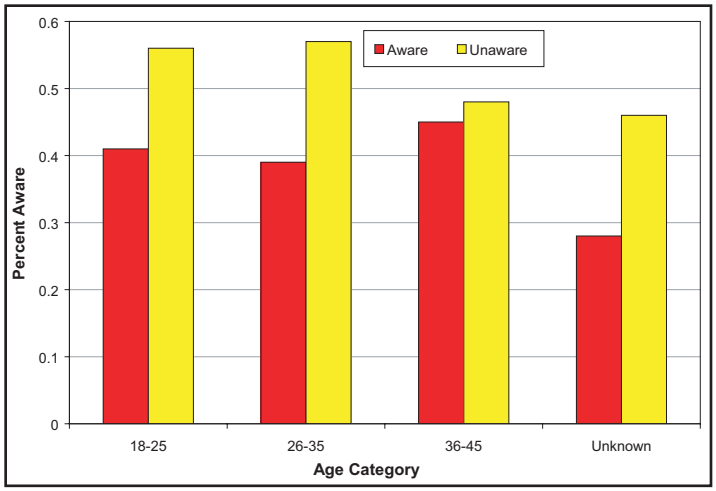

Figure 3. Percent of responders to the survey who are (red) or are not (yellow) aware of fish consumption advisories according to age group.
Source: Wisconsin Department of Health and Family Services

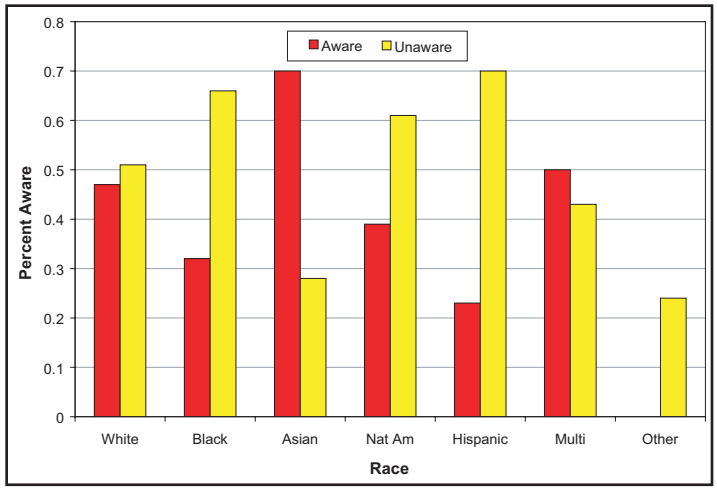

Figure 4. Percent of responders to the survey who are (red) or are not (yellow) aware of fish consumption advisories according to race.
Source: Wisconsin Department of Health and Family Services

precludes definitive findings, the woman consuming the most fish (at least 1 sport-caught fish meal per week) had the highest concentration of DDE and the only positive finding of PCB in her serum. The woman consuming the fewest fish per year (6 to 18 fish meals) had the lowest concentration of DDE in her serum, and no PCBs were detected (Table 2).

Fish meals / 3 months Sport-caught (Y/N)	Min (µg/g)	Ave (µg/g)	Max (µg/g)	Number of Respondents	Ave no. fish meals
0	0.00	0.07	0.24	14	0
1-9 (N)	0.04	0.16	0.59	28	2.3
1-9 (Y)	0.03	0.30	0.99	7	2.4
10+ (N)	0.04	0.33	1.23	7	12.8
10+ (Y)	0.09	0.38	1.53	9	8.11

Table 1. Concentration of mercury in hair samples from women who consumed sport-caught or not sport-caught fish during the previous three months.
Source: Wisconsin Department of Health and Family Services

Effects on Aboriginals of the Great Lakes (EAGLE) Project

A similar study was conducted by a partnership between the Assembly of First Nations, Health Canada and First Nations in the Great Lakes basin between 1990 and 2000 to examine the effects of contaminants on the health of the Great Lakes Aboriginal population (Davies and Phil 2001). The Contaminants in Human Tissues Program (CHT), a major component of the EAGLE Project, identified three main goals: to determine the levels of environmental contaminants in the tissues of First Nations people in the Great Lakes basin; to correlate these levels with freshwater fish and wild game consumption; and, to provide information and advice to First Nations people on the levels of environmental contaminants found in their tissues.

Person ID	Fish Meals	PCB (µg/l)	DDE (µg/l)	Mercury (µg/l)
1	Commercial = 1/week Sport Caught = none	0.0	0.34	<5
2	Commercial = 5/month Sport Caught = 30/year	0.0	0.40	<5
3	Commercial =<6/Year Sport Caught = 6-12/Year	0.0	0.25	<5
4	Commercial = 1/week Sport Caught = 1/week	0.4	1.20	<5
5	Commercial = 4/month Sport Caught = 2/month	0.0	0.49	<5

Table 2. Number of fish meals consumed and concentration of PCBs, DDE and mercury in blood serum of 5 women who participated in the WIC study.
Source: Wisconsin Department of Health and Family Services

The EAGLE project also analyzed hair samples for levels of mercury and blood serum for levels of PCBs and DDEs. A survey was also used to identify frequency of fish and wildlife consumption. However, the EAGLE project analyzed both male and female voluntary participants from 26 First Nations in the Great Lakes basin. The participants were volunteers, not selected on a random basis, and the project did not specifically target only fish eaters.

Key findings of the study included:

- Males consumed more fish than females and carried greater contaminant levels.
- No significant relationship was found between total fish or wild game consumption and the contaminant levels in the body.
- Levels of mercury in hair from First Nations people in the Canadian portion of the Great Lakes basin suggest the levels have decreased since 1970.
- PCBs and DDE were the most frequently appearing contaminants in the serum samples.
- Increased age of participants correlated with increased contaminant concentrations.
- Mean levels of PCBs reported in the EAGLE CHT Program were lower than or within the similar range of PCBs in fish-eaters in other Canadian health studies (Great Lakes, Lake Michigan, and St. Lawrence).
- Most people have levels of contaminants that were within Health Canada's guidelines for PCBs in serum and mercury in hair.
- Levels of DDE were similar to levels found in other Canadian health studies.
- There was little difference between serum levels of DDE in male and female participants.

ATSDR-sponsored Studies

The Agency for Toxic Substances and Disease Registry (ATSDR) and the U.S. Environmental Protection Agency established the Great Lakes Human Health Effects Research Program through legislative mandate in September 1992 to "assess the adverse effects of water pollutants in the Great Lakes system on the health of persons in the Great Lakes States" (ATSDR 2006a). This program assesses critical pollutants of concern, identifies vulnerable and sensitive populations, prioritizes areas of research, and funds research projects. Results from several recent Great Lakes biomonitoring research projects are summarized here.

Data collected from 1980 to 1995 from Great Lakes sport fish eaters showed a decline in serum PCB levels from a mean of 24 ppb in 1980 to 12 ppb in 1995. This decline was associated with an 83% decrease in the number of fish meals consumed (Tee *et al*. 2003).

A large number of infants (2716) born between 1986 and 1991 to participants of the New York State Angler Cohort Study were studied with respect to duration of maternal consumption of contaminated fish and potential effects on gestational age and birth size. The data indicated no significant correlations between gestational age or birth size in these infants and their mother's lifetime consumption of fish. The researchers noted that biological determinants such as parity, and placental infarction and maternal smoking were significant determinants of birth size (Buck *et al*. 2003).

The relationship between prenatal exposure to PCBs and methylmercury and performance on the McCarthy Scales of Children's Abilities was assessed in 212 children. Negative associations between prenatal exposure to methylmercury and McCarthy performance were found in subjects with higher levels of prenatal PCB exposure at 38 months. However, no relationship between PCBs and methylmercury and McCarthy performance was observed when the children were reassessed at 54 months. These results partially replicated the findings of others and suggest that functional recovery may occur. The researchers concluded that the interaction between PCBs and methylmercury can not be considered conclusive until it has been replicated in subsequent investigations (Steward *et al*. 2003b).

Response inhibition in preschool children exposed parentally to PCBs may be due to incomplete development of their nervous system. One hundred and eighty-nine children in the Oswego study were tested using a continuous performance test. The researchers measured the splenium of the corpus callosum, a pathway in the brain implicated in the regulation of response inhibition, in these children by magnetic resonance imaging. The results indicated the smaller the splenium, the larger the association between PCBs and the increased number of errors the children made on the continuous performance test. The researchers suggest if the association between PCBs and response inhibition is indeed causal, then children with suboptimal development of the splenium may be particularly vulnerable to these effects (Stewart *et al*. 2003a).

Long term consumption of fish, even at low levels, contributes significantly to body burden levels (Bloom *et al*. 2005).

- American Indians were assessed for their exposure to PCBs via fish consumption by analysis of blood samples and the Caffeine Breath Test (CBT). Serum levels of PCB congers #153, #170 and #180 were significantly correlated with CBT values. CBT values may be a marker for early biological effects of exposure to PCBs (Fitzgerald *et al*. 2005).
- Maternal exposure via fish consumption to DDE and PCBs indicated that only DDE was associated with reduced birth weight in infants (Weisskopf *et al*. 2005).
- The association between maternal fish consumption and the risk of major birth defects among infants was assessed in the New York State Angler Cohort Study. The results indicated mothers who consumed 2 or more fish meals per month had a significantly elevated risk for male children being born with a birth defect (males: Odds Ratio = 3.01, in comparison to female children: Odds Ratio = 0.73, Mendola *et al*. 2005).

Pressures

Contaminants of emerging concern, such as certain brominated flame-retardants, are increasing in the environment and may have negative health impacts. According to a recent study conducted by Environment Canada, worldwide exposure to polybrominated diphenyl ethers (PBDEs, penta) is highest in North America with lesser amounts in Europe and Asia. Food consumption is a significant vector for PBDE exposure in addition to other sources. The survey analyzed PBDE concentration in human milk by region in Canada in 1992 and in 2002 and showed a tenfold increase in concentration in Ontario (Ryan 2004).

The health effects of contaminants such as endocrine disruptors are somewhat understood. However, there is little known about the synergistic or additive effects of bioaccumulating toxic chemicals. Additional information about toxicity and interactions of a larger suite of chemicals, with special attention paid to how bioaccumulating toxic chemicals work in concert, is needed to better assess threats to human health from contaminants in the Great Lakes basin ecosystem. ATSDR has developed 5 categories of interaction profiles for toxic substances, including volatile organic compounds, metals, pesticides, and persistent contaminants found in breast milk and fish (ATSDR 2006b).

Management Implications

There have been many small-scale studies regarding human biomarkers and bioaccumulating toxic chemicals. However, to this date, there have been no large-scale or basin-wide studies that can provide a larger picture of the issues facing the citizens of the basin. It is important that those in management positions in federal, state, provincial, and tribal governments and universities foster cooperation and collaboration to identify gaps in existing biomonitoring data and to implement larger, basin-wide monitoring efforts. A Great Lakes environmental health tracking program, similar to the Center for Disease Control (CDC) Environmental Health Tracking Program, should be established by key Great Lakes partners.

Comments from the author(s)

A region-specific biomonitoring program, similar to the CDC's National Health and Nutrition Examination Survey (NHANES) project could provide needed biomonitoring information and fill in data gaps.

It is important that additional studies assessing the levels of bioaccumulative toxic chemicals through biomarkers be conducted on a much larger scale throughout the basin. In order to build on the WIC study, a question about fish consumption from restaurants would be important to be included in future surveys. Because all states have WIC clinics, or something similar, the WiDPH monitoring tool could be implemented basin-wide.

In the future, ATSDR's Great Lakes Human Health Effects Research Program plans to continue to provide research findings to public health officials to improve their ability to assess and evaluate chemical exposure in vulnerable populations. ATSDR also plans to focus on research priorities of children's health, endocrine disruptors, mixtures, surveillance, and identification of biomarkers that reflect exposure, effect, and susceptibility. In addition, the program will use established cohorts to monitor changes in body burdens of persistent toxic substances and in specified health outcomes, and to develop and evaluate new health promotion strategies and risk communication tools.

Acknowledgments

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Last Updated

State of the Great Lakes 2007